

METEORITE DUNITE BRECCIA MIL 03443: A PROBABLE CRUSTAL CUMULATE CLOSELY RELATED TO DIOGENITES FROM THE HED PARENT ASTEROID. David W Mittlefehldt, Astromaterials Research Office, NASA/Johnson Space Center, Houston, Texas, USA, (david.w.mittlefehldt@nasa.gov).

Introduction: There are numerous types of differentiated meteorites, but most represent either the crusts or cores of their parent asteroids. Ureilites, olivine-pyroxene-graphite rocks, are exceptions; they are mantle restites [1]. Dunite is expected to be a common mantle lithology in differentiated asteroids. In particular, models of the eucrite parent asteroid contain large volumes of dunite mantle [2-4]. Yet dunites are very rare among meteorites, and none are known associated with the howardite, eucrite, diogenite (HED) suite. Spectroscopic measurements of 4 Vesta, the probable HED parent asteroid, show one region with an olivine signature [5] although the surface is dominated by basaltic and orthopyroxenitic material equated with eucrites and diogenites [6]. One might expect that a small number of dunitic or olivine-rich meteorites might be delivered along with the HED suite.

The 46 gram meteoritic dunite MIL 03443 (Fig. 1) was recovered from the Miller Range ice field of Antarctica. This meteorite was tentatively classified as a mesosiderite because large, dunitic clasts are found in this type of meteorite, but it was noted that MIL 03443 could represent a dunite sample of the HED suite [7]. Here I will present a preliminary petrologic study of two thin sections of this meteorite.



Figure 1. MIL 03443 after initial processing. Dark clasts are olivine mineral fragments.

Petrology: MIL 03443 is a fragmental breccia composed dominantly of olivine, but containing minor orthopyroxene, chromite, troilite, and accessory metal and diopside (Fig. 2). The olivine was originally coarse-grained – fragments up to 2.5 mm in size are present in the thin sections and clasts of ~4 mm are visible in hand sample (Fig. 1). Orthopyroxene is smaller – the largest grain found is ~0.5 mm in longest dimension. The largest chromite grain found is 0.4 mm in maximum dimension. Chromite is poikilitically enclosed in olivine and orthopyroxene. Small diopside grains up to 0.1 mm in maximum dimension are found as inclusions in olivine (Fig. 3). Troilite occurs commonly as composite inclusions with chromite in olivine, and less commonly in the fragmental matrix.

Metal is very rare, and occurs as grains a few microns in size associated with troilite.

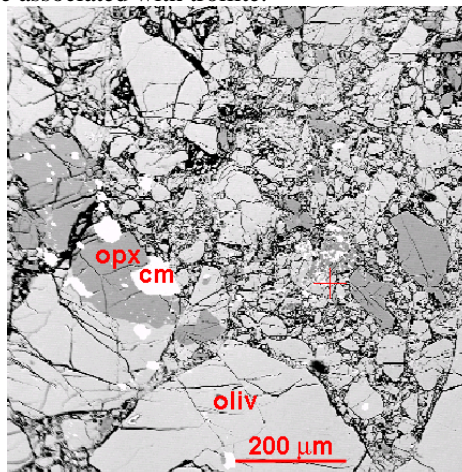


Figure 2. BSE image of MIL 03443 showing its general fragmental breccia texture, and primary texture between olivine, orthopyroxene and chromite.

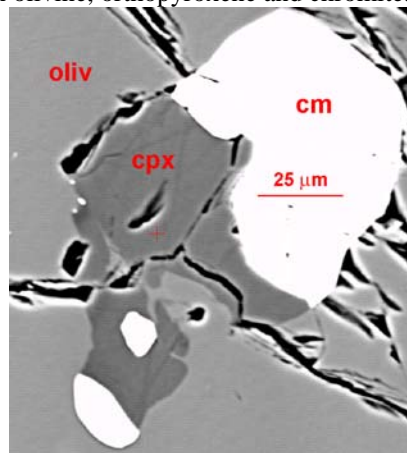


Figure 3. BSE image of MIL 03443 showing composite diopside-chromite inclusion enclosed in olivine.

The phases are homogeneous in composition. The total range in olivine mg# is 73.6-74.5 with a mean for 14 grains of 73.9. The mean Fe/Mn ratio is 42.2. The mean of 10 orthopyroxene grains is mg# 77.6 with 3.0% Wo component and Fe/Mn of 26.2. The single diopside grain analyzed is $\text{Wo}_{42.8}\text{En}_{47.7}\text{Fs}_{9.5}$ with an Fe/Mn of 19.9.

MIL 03443 olivine compositions fall in the overlap region between howardite and mesosiderite olivine clasts in FeO/MnO vs. mg# and are similar to olivine grains from diogenites (Fig. 4). Pyroxene compositions of MIL 03443 fall within the range of those from

diogenites (Fig. 5), as well as for coarse-grained clasts from howardites and mesosiderites (not shown).

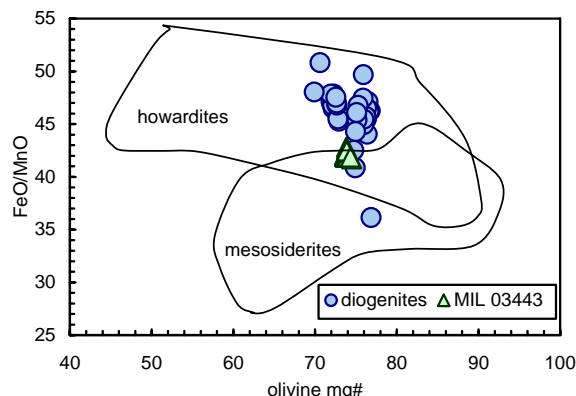


Figure 4. Comparison of MIL 03443 olivine compositions with those from diogenites and fields for clasts from howardites and mesosiderites [8-11].

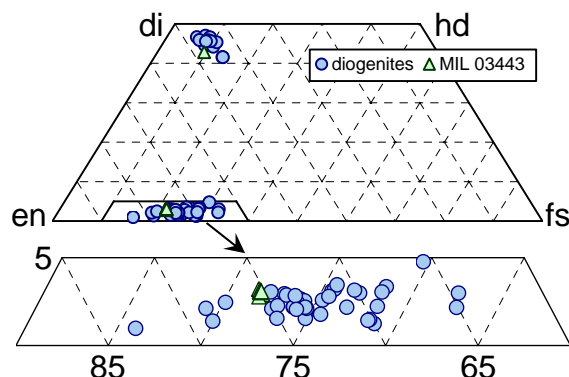


Figure 5. Comparison of MIL 03443 pyroxenes with those from diogenites. Diogenite data from [10-14].

Discussion: Large, coarse-grained dunite and olivine clasts are a minor component of mesosiderites [8]. The most spectacular examples are brecciated dunite clasts and a 10 cm olivine clast from Mount Padbury [15]. The latter clast is larger than MIL 03443. In contrast, olivine or dunite clasts are rare in howardites and are typically <0.1 mm in size [8].

Olivine compositions of MIL 03443 fall within the overlap region of howardite and mesosiderite clasts (Fig. 4) and thus do not allow us to distinguish between these types as possible close relatives. MIL olivines fall at the edge of the narrow field of diogenite olivines (Fig. 4). Pyroxene compositions similarly do not allow us to distinguish between a mesosiderite or a HED source for MIL 03443. Coarse-grained orthopyroxenes from these meteorite types overlap in composition [1]. MIL 03443 plots within the field for diogenites at the magnesian edge of the dense cluster of pyroxene compositions (Fig. 5).

As metal-silicate polymict breccias, one characteristic of clasts from mesosiderites is that they com-

monly contain metal and troilite derived from the matrix, especially in breccia clasts. This is true of the brecciated dunite clasts from Mount Padbury, although the amount of metal and troilite is not given [15]. The paucity of metal in MIL 03443 then favors an origin on the HED, not the mesosiderite, parent asteroid. In addition, the common occurrence of troilite as composite chromite-troilite inclusions in silicates is similar to textures in HED meteorites, and different from the more common occurrence of troilite in the matrix of fragmental breccia clasts in mesosiderites. This is not compelling, but is suggestive that MIL 03443 is part of the HED suite.

A dunite could have been formed as either a mantle restite remaining after an extensive degree of partial melting, or as an olivine cumulate from a mafic-ultramafic parent melt. Mineral compositions favor the latter scenario. Pyroxene compositions are similar to the magnesian edge of the dense diogenite cluster, but several, much more magnesian diogenites exist (Fig. 5). Similarly, mesosiderite orthopyroxene clasts more magnesian than MIL 03443 exist. A coarse-grained clast from Bondoc has an mg# of 81.4 [14] compared to 77.6 for MIL 03343. Olivine compositions for MIL 03443 similarly are less magnesian than the extremes known from howardites or mesosiderites, but only marginally so compared to diogenites (Fig. 4). In a partial melting scenario, a mantle restite ought to be more magnesian than any cumulates from the melts. Thus, the existence of olivines and pyroxenes in mesosiderites and HED more magnesian than those of MIL 03443 imply that the latter is a cumulate.

Mineral compositions in MIL 03443 suggest a close relationship with diogenites, or diogenite-like protoliths from the mesosiderite parent asteroid. MIL 03443 plausibly represents an olivine-rich crustal lithology intermixed with diogenitic rocks from the HED, or possibly mesosiderite, parent asteroid.

References: [1] Mittlefehldt D.W. et al. (1998) *Rev. Min.*, 36, ch. 4. [2] Jones J.H. (1984) *GCA*, 48, 641. [3] Righter K. & Drake M.J. (1997) *MAPS*, 32, 929. [4] Ruzicka A. et al. (1997) *MAPS*, 32, 825. [5] Gaffey M.J. (1997) *Icarus*, 127, 130. [6] Binzel R.P. et al. (1997) *Icarus*, 128, 95. [7] McBride K. & McCoy T. (2006) *Ant. Met. Newsletter*, 29, no. 2. [8] Delaney J.S. et al. (1980) *PLPSC*, 11, 1073. [9] Mittlefehldt D.W. (1980) *EPSL*, 51, 29. [10] Mittlefehldt D.W. (1994) *GCA*, 58, 1537. [11] Mittlefehldt D.W. (2000) *MAPS*, 35, 901. [12] Mittlefehldt D.W. & Lindstrom M.M. (1993) *Proc. NIPR Sym. Ant Met.*, 6, 268. [13] Domanik K. et al. (2004) *MAPS*, 39, 567. [14] Mittlefehldt D.W., unpublished data. [15] McCall G.J.H. (1966) *Min. Mag.*, 35, 1029.